

EMB190 Alerting Issues – Stall

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	When the current deceleration rate will cause airspeed to be below minimum safe speed (i.e., in the low speed awareness region of the PFD speed tape) within the next 10 seconds, the airspeed trend arrow turns from green to amber	Airspeed trend projection of 1.13 Vs within the next 10 seconds				Airspeed increase
	When the current deceleration rate will cause airspeed to be below minimum safe speed (i.e., in the low speed awareness region of the PFD speed tape) within the next 10 seconds, or when slowing below actual minimum safe speed, PFD digital airspeed readout turns from green to amber	Airspeed trend projection of 1.13 Vs within the next 10 seconds, or at approximately 1.13 Vs (g-compensated)	The mach indicator has different speed threshold for turning amber, compared to the airspeed indicator			Airspeed increase
	Slowing below minimum safe speed, the PFD pitch limit indicator appears and turns from green to amber	AOA equivalent to approximately 1.13 Vs (g-compensated)				AOA reduction
	When the current deceleration rate will cause airspeed to approach stall (be at or below stickshaker speed) within the next 10 seconds, the digital indicated airspeed readout turns from amber to red inverse	Airspeed trend projection at or below stickshaker speed (g-compensated)	The mach indicator has different speed threshold for turning red, compared to the airspeed indicator			Airspeed increase
	Approaching stall, the PFD pitch limit indicator turns from amber to red inverse	Stickshaker limit value of AOA				AOA reduction
	Approaching stall, the PFD digital mach readout turns from green to amber	Stickshaker limit value of AOA	The mach indicator has different speed threshold for turning amber, compared to the airspeed indicator			AOA reduction

EMB190 Alerting Issues – Stall

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Approaching stall, the PFD "AP" FMA turns from green to red (flashing for the first five seconds)	Stickshaker limit value of AOA	Disconnection of the autopilot is a consequence of the stall, not a cause, which can be confusing.	Reversion to manual flying can be a workload spike and distraction		Cancelled by pressing an AP disconnect button
	Approaching stall, MFD EICAS caution message AP FAIL	Stickshaker triggers autopilot disconnect	Disconnection of the autopilot is a consequence of the stall, not a cause, which can be confusing.	Reversion to manual flying can be a workload spike and distraction		
	At stall onset, PFD digital mach readout turns from amber to red inverse	Approximately stall speed (g-compensated)	The mach indicator has different speed threshold for turning red, compared to the airspeed indicator. Note: this is per manual documentation, but the in the simulator the color change threshold for mach is the same as for the airspeed readout.			Airspeed increase
Aural Alerts	Stick shaker (sound of)	Stall protection system limit value of AOA				AOA reduction
	Voice alert "Autopilot"	Stall protection system limit value of AOA (stickshaker threshold)	Disconnection of the autopilot is a consequence of the stall, not a cause, which can be confusing.	Reversion to manual flying can be a workload spike and distraction		

EMB190 Alerting Issues – Stall

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Tactile Alerts	Stick shaker	Stall protection system limit value of AOA				AOA reduction
Visual Cues	When slowing below minimum safe speed, the indicated airspeed enters the amber region of the speed tape	Approximately 1.13 Vs (with less than the indicated Vs margin when > .45 Mach), with g-compensated movement of the speed band				
	Approaching stall, indicated airspeed enters the red region of the speed tape	Stickshaker speed, with g-compensated movement of the speed band				
	PFD indications of uncommanded pitch		Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions.			
	Roll rate on PFD		Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions.		Uncommanded roll cues masked by autopilot roll inputs until the a/p disconnects (appears as wheel deflection, see below); however, rapid roll may accompany a/p disconnect at the stall.	

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1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	Sink rate on PFD vertical speed display		Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions.			
	Wheel may move opposite the roll.	Wheel movement from autopilot inputs in response to uncommanded roll, if roll occurs prior to stickshaker/autopilot disconnect				
Aural Cues	None					
Tactile/ Somatic Cues	Aerodynamic buffet	AOA (natural)	Can be confused with high speed buffet			Reduction of AOA
	Heavier column forces to increase AOA	Stickshaker limit value of AOA		This is a fly-by-wire function in Normal mode; failure of this function is annunciated on EICAS		

EMB190 Alerting Issues – Stall

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

Expected Pilot Response(s)

- Disconnect autopilot and autothrottle
- Apply nose down pitch control until stall warning is eliminated
- Apply nose-down trim as needed
- Roll wings level
- Adjust thrust as needed
- Check speedbrakes retracted
- Return to the desired flightpath

Possible sources of confusion with regard to pilot response(s)

- Autopilot may trim into low airspeed condition before disconnecting, resulting in nose-up pitch rate and greater need to re-trim during recovery.
- Autopilot may disconnect while holding wheel input, resulting in rapid roll at the time of disconnection.
- Uncommanded pitch/roll and sink rate cues also can result from other events besides stall, thus not necessarily signaling stall recovery to the pilot. Also these cues can draw the pilot's attention away from stall diagnosis or recovery actions.
- High altitude stall may require greater nose-down input than the stalls trained in the simulator.
- High altitude stall may lead to high speed buffet during recovery, with cues similar to low-speed buffet but different recovery actions required.
- Erroneous pilot inputs (i.e., nose-up pitch inputs) can exacerbate stall or prevent recovery.

How does pilot know condition is resolved/recovered?

- Cessation of stall warning alerts

Issues with regard to multiple concurrent non-normal conditions

- Condition may devolve to engine surge and/or wing-walking (roll reversals from stall exacerbated by pilot rudder/wheel inputs).
- Possible passenger injuries and aircraft damage.

EMB190 Alerting Issues – Stall

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
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Visual Alerts	When the current deceleration rate will cause airspeed to be below minimum safe speed (i.e., in the low speed awareness region of the PFD speed tape) within the next 10 seconds, the airspeed trend arrow turns from green to amber	Airspeed trend projection of 1.13 Vs within the next 10 seconds				Airspeed increase
	When the current deceleration rate will cause airspeed to be below minimum safe speed (i.e., in the low speed awareness region of the PFD speed tape) within the next 10 seconds, or when slowing below actual minimum safe speed, PFD digital airspeed readout turns from green to amber	Airspeed trend projection of 1.13 Vs within the next 10 seconds, or at approximately 1.13 Vs (g-compensated)	The mach indicator has different speed threshold for turning amber, compared to the airspeed indicator			Airspeed increase
	Slowing below minimum safe speed, the PFD pitch limit indicator appears and turns from green to amber	AOA equivalent to approximately 1.13 Vs (g-compensated)				AOA reduction
	When the current deceleration rate will cause airspeed to approach stall (be at or below stickshaker speed) within the next 10 seconds, the digital indicated airspeed readout turns from amber to red inverse	Airspeed trend projection at or below stickshaker speed (g-compensated)	The mach indicator has different speed threshold for turning red, compared to the airspeed indicator			Airspeed increase
	Approaching stall, the PFD pitch limit indicator turns from amber to red inverse	Stickshaker limit value of AOA				AOA reduction
	Approaching stall, the PFD digital mach readout turns from green to amber	Stickshaker limit value of AOA	The mach indicator has different speed threshold for turning amber, compared to the airspeed indicator			AOA reduction

EMB190 Alerting Issues – Stall

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	At stall onset, PFD digital mach readout turns from amber to red inverse	Approximately stall speed (g-compensated)	The mach indicator has different speed threshold for turning red, compared to the airspeed indicator. Note: this is per manual documentation, but the in the simulator the color change threshold for mach is the same as for the airspeed readout.			Airspeed increase
Aural Alerts	Stick shaker (sound of)	Stall protection system limit value of AOA				AOA reduction
	GPWS "Bank angle"	Bank angle >35 degrees		This is not an alert to the stall, but rather to the excessive bank angle from the roll upset		Reduction of bank angle
Tactile Alerts	Stick shaker	Stall protection system limit value of AOA				AOA reduction
Visual Cues	When slowing below minimum safe speed, the indicated airspeed enters the amber region of the speed tape	Approximately 1.13 Vs (with less than the indicated Vs margin when > .45 Mach), with g-compensated movement of the speed band				
	Approaching stall, indicated airspeed enters the red region of the speed tape	Stickshaker speed, with g-compensated movement of the speed band				

EMB190 Alerting Issues – Stall

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	PFD indications of uncommanded pitch		Uncommanded pitch/roll and sink rate cues from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues).	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
	Roll rate on PFD		Uncommanded pitch/roll and sink rate cues from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues).	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
	Sink rate on vertical speed display		Uncommanded pitch/roll and sink rate cues from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues).	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
Aural Cues	Wind noise		Wind noise is not a reliable cue to angle-of-attack, but loud wind noise may potentially mislead pilots into thinking that the aircraft is not stalled during a high-load factor stall			
Tactile/ Somatic Cues	Unusual wheel/column forces		Changes in the required control forces from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues).	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		

EMB190 Alerting Issues – Stall

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Tactile/ Somatic Cues	Aerodynamic buffet	AOA (natural)	Buffet cues from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues). Also, may be confused with high speed buffet.	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		

Expected Pilot Response(s)

- Disconnect autopilot and autothrottle
- Apply nose down pitch control until stall warning is eliminated
- Apply nose-down trim as needed
- Roll wings level
- Adjust thrust as needed
- Check speedbrakes retracted
- Return to the desired flightpath

Possible sources of confusion with regard to pilot response(s)

- Stall in nose-low condition (or devolving to nose-low condition) can require counter-intuitive pitch-down control inputs.
- If terrain proximity, the pilot may have to pitch down while being presented with a "Pull Up" GPWS warning.
- Erroneous pilot inputs (i.e., nose-up pitch inputs) can exacerbate stall or prevent recovery.

How does pilot know condition is resolved/recovered?

- Termination of stall warning alerts

Issues with regard to multiple concurrent non-normal conditions

- Recovery from stall condition must be followed immediately by recovery from nose-low, high bank upset condition.
- Possible passenger injuries and aircraft damage.

EMB190 Alerting Issues – Stall

3. Initiating Condition: Wing ice accumulation

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	None: Pitch limit indicator is present on the PFD but may not be touching the aircraft symbol when the stall occurs (suggesting to the pilot that the aircraft is not stalling)		The expected alerts and cues will be absent		Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	
Aural Alerts	None		The expected alerts and cues will be absent		Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	
Tactile Alerts	None		The expected alerts and cues will be absent	Pilots are trained extensively to associate stick shaker as trigger to stall recovery; in absence of stick shaker (warning system failure or stall at lower-than-nominal AOA) they may not interpret the secondary cues of buffet, roll, etc. as being related to stall.	Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	
Visual Cues	None: airspeed appears to be adequate but is not; airplane may stall while indicated airspeed is in the amber band but not in or touching the red band		The expected alerts and cues will be absent	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.	Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	

EMB190 Alerting Issues – Stall

3. Initiating Condition: Wing ice accumulation – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	PFD/ADI indications of uncommanded pitch		In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall	Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
	Roll rate on PFD/EADI		In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall	Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
	Sink rate on vertical speed display		In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall	Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
Aural Cues	None					
Tactile/ Somatic Cues	Buffet; unusual wheel/column forces (autopilot off)	AOA (natural)	In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall	Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		Reduction of AOA

EMB190 Alerting Issues – Stall

3. Initiating Condition: Wing ice accumulation – Cont.

Expected Pilot Response(s)

- Disconnect autopilot and autothrottle
- Apply nose down pitch control until stall warning is eliminated
- Apply nose-down trim as needed
- Roll wings level
- Adjust thrust as needed
- Check speedbrakes retracted
- Return to the desired flightpath

Possible sources of confusion with regard to pilot response(s)

- In the absence of the usual salient alerts, the pilots may not realize that the aircraft is stalled.
- Erroneous pilot inputs (i.e., nose-up pitch inputs) can exacerbate stall or prevent recovery.

How does pilot know condition is resolved/recovered?

- Difficult to know, related to cessation of uncommanded pitch/roll/sink

Issues with regard to multiple concurrent non-normal conditions

- Condition may devolve to engine surge and/or wing-walking (roll reversals from stall exacerbated by pilot rudder/wheel inputs).
- Possible passenger injuries and aircraft damage.

EMB190 Alerting Issues – Stall

4. Initiating Condition: False stall warning during takeoff rotation

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Slowing below minimum safe speed (falsely indicated), the PFD pitch limit indicator appears and turns from green to amber	AOA equivalent to approximately 1.13 Vs (g-compensated)	Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.		Inhibition/suppression not relevant because the alert is false	Alert or cue is not terminated as it is invalid
	When the current deceleration rate will cause airspeed to approach stall (be at or below the falsely calculated stickshaker speed) within the next 10 seconds, the digital indicated airspeed readout turns from amber to red inverse	Airspeed trend projection at or below stickshaker speed (g-compensated)	Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.		Inhibition/suppression not relevant because the alert is false	Alert or cue is not terminated as it is invalid
	Approaching the falsely calculated AOA limit value for stall, the PFD pitch limit indicator turns from amber to red inverse	Stickshaker limit value of AOA	Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.		Inhibition/suppression not relevant because the alert is false	Alert or cue is not terminated as it is invalid
	Approaching the falsely calculated AOA limit value for stall, the PFD digital mach readout turns from green to amber	Stickshaker limit value of AOA	Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.		Inhibition/suppression not relevant because the alert is false	Alert or cue is not terminated as it is invalid

EMB190 Alerting Issues – Stall

4. Initiating Condition: False stall warning during takeoff rotation – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Aural Alerts	Stick shaker, sound of (false indication)	Stall protection system limit value of AOA	Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.		Inhibition/suppression not relevant because the alert is false	Alert or cue is not terminated as it is invalid
Tactile Alerts	Stick shaker (false indication)	Stall protection system limit value of AOA	Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.		Inhibition/suppression not relevant because the alert is false	Alert or cue is not terminated as it is invalid
Visual Cues	Normal vertical speed, altimeter, and airspeed indications on PFD, as well as view through the windshield of the aircraft climbing (if VMC) are subtle cues that the aircraft is not stalling		Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.			Alert or cue is not terminated as it is invalid
Aural Cues	None					

EMB190 Alerting Issues – Stall

4. Initiating Condition: False stall warning during takeoff rotation – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Tactile/Somatic Cues	Normal vertical acceleration from rotation into climb is a subtle cue that the aircraft is not stalling		Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.			Alert or cue is not terminated as it is invalid

Expected Pilot Response(s)

- Ignore false alerts and cues.
- Do not reject takeoff.

Possible sources of confusion with regard to pilot response(s)

- Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.
- Pilots are trained to respond to stall warnings/alerts immediately and without deliberation, decreasing the likelihood of identifying the false warning through effortful analysis and suppressing the reaction to the false warning.
- Split-second decision to perform a late rejection or continue.

How does pilot know condition is resolved/recovered?

- Observe normal takeoff and climb performance

Issues with regard to multiple concurrent non-normal conditions

- None unless pilot takes unneeded actions, such as high speed RTO.